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A R T I C U L O

Survey of glass science and industry in the Czech Republic

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The article gives the survey of glass science, research and glass industry in the Czech Republic in years 1996 and 1997. The main economic data, regional location of glass industry in CR and its structure from the point of view of individual production commodities are introduced in it. The final chapter deals with the stay of glass science and research in CR. The main research institutes including their research activities are mentioned.

Keywords: glass, science, industry, production.

Situación de la investigación e industria del vidrio en la República Checa

En el trabajo se hace una revisión de la situación de la industria y la ciencia del vidrio en la República Checa, en los años 1996 y 1997. Se indican los principales datos económicos y la localización regional. de la industria checa del vidrio así como las principales unidades productivas. En la parte final se refleja el estado de la ciencia e investigación sobre vidrio en la República Checa. Se indican los principales centros de investigación y sus líneas de trabajo.

Palabras clave: vidrio, ciencia, investigación, industria, producción.

1. HISTORY

Manufacture of glass and gradual introduction of new knowledge into glass processing technology connected with it has had a long tradition in the Czech Republic, coming down to the Middle Ages. The fact that the glass manufacture has been developed in Bohemia as in one of the first territories in Europe is pointed out in the article of Prof. W.E.S. Turner "On the origin and development of glass-making" [1] from which it is obvious how the glass manufacture in the world, and particularly in Europe, has gradually developed - see Fig. 1. Glass has been melted from the 14th century, which has been proved by the findings of medieval glass melting furnaces and glass products, or cullet. Due to a large archaeological investigation, the scientists were able to collect a lot of data which became the base of the medieval glass melting furnace built in 1991 and 1992 [2] and working under the same conditions as in the Middle Ages, i.e. that it was heated only by wood. There has been produced medieval glass of very good quality in this furnace. The realization of the mentioned project lead by the members of the "History of glass technologies" section of the Czech Glass Society in which many historians and glass experts have been involved has brought a clear evidence that it was possible to melt glass in Bohemia during the Middle Ages.

Since the half of the 16th century, the glass manufacture in Bohemia has reached such a high level that in a lot of European countries there were sold sumptuous chalices and household glassware produced by Czech glass works. At his

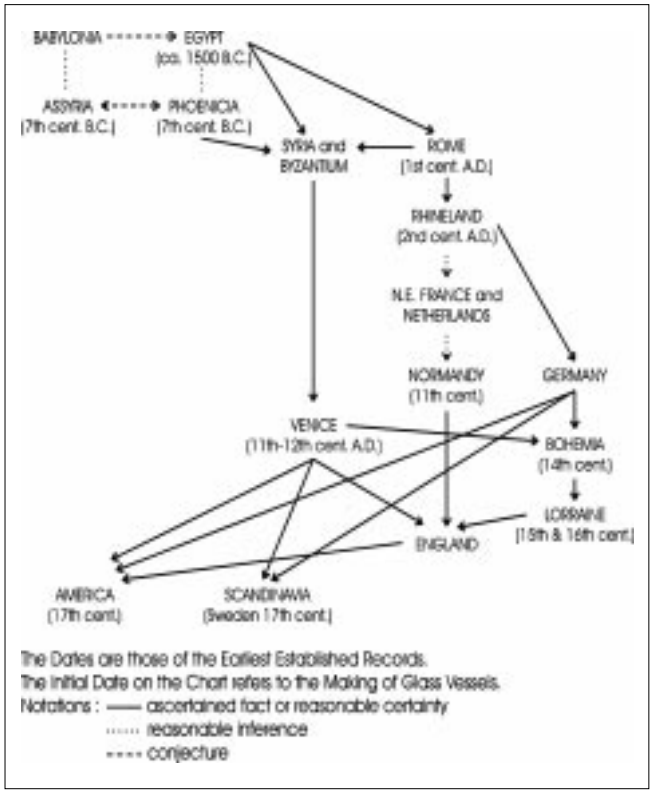

Figure 1. Scheme and industry of glass industry development.

time, there also started the development of typical Czech glass sold under the trade mark "Böhemian Crystal", "Böhmisches Kristallglas" or "Crystal du Bohéme" which is produced and sold under these trademarks even nowadays.

2. PRESENT TIME

At present, the Czech glass industry is to a great extent a technical branch and it serves as an important supplier of glass for construction, food and automotive industries. The rate of industrial glass, i.e. construction, container and automotive glass, equals at present 84% of the total glass production in the Czech Republic – see Fig. 2. This value approaches the same value in EU countries, where it reaches 90% - see Fig. 3. Figures 4 and 5 show the position of glass and ceramics industry within the processing industry in the Czech Republic in 1997 and 1998. It is obvious from these figures that glass and ceramics industry in CR occupies the important position corresponding with that of glass and ceramics industry in other European countries.

2.1. Characteristics of glass production in physical units

According to EU, in CR the production of glass industry in physical units is evaluated, too - see Table 1 and Figs. 6, 7 and 8.

2.2. Economic and production parameters

The analysis of economic and production parameters has been done on the base of data files obtained from the glass industry organizations of all extents. The first data are those concerning proceeds from the sale of their own articles - see Table 2 and Fig. 9, 10 and 11.

Fig. 12 shows the development of proceeds from the sale of the own articles during the period 1991 - 1998 in the whole glass industry.

Glass export is the next important parameter. Values from the years 1996, 1997 and 1998 are introduced in Table 3 and Figs. 13,14 and 15.

Table 4 and Figs. 16, 17 and 18 give the survey of the structure of individual commodities of glass industry import.

When comparing values in Figs 13 up to 18, we can see that the rate of increase of glass industry commodities import and export was different in the years 1996 and 1997. Unfortunately, the import dynamics still prevails the export one even though the situation has been coming better if compared with past years; e.g. the balance of glass industry foreign trade increased in 1997 by 12% in comparison with 1996 and in 1998 by 15.08% in comparison with 1997.

The mentioned development of the glass industry in the 90-ies was accompanied by the decrease of employment - see Table 5 and Fig. 19, 20 and 21.

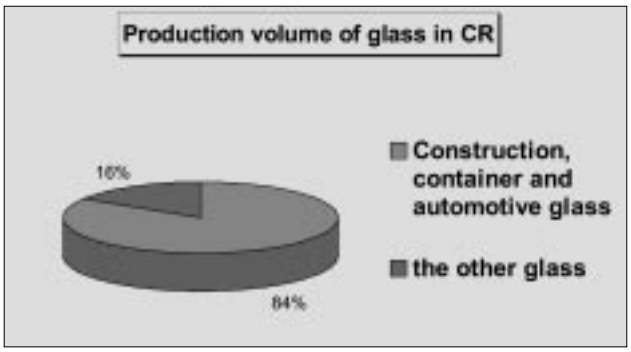

Figure 2.Production volume of glass in CR.

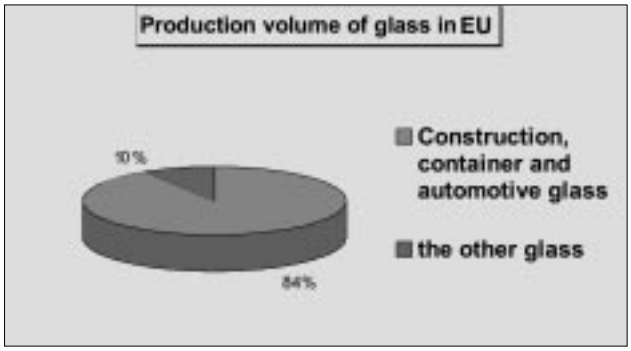

Figure 3.Production volume of glass in EU.

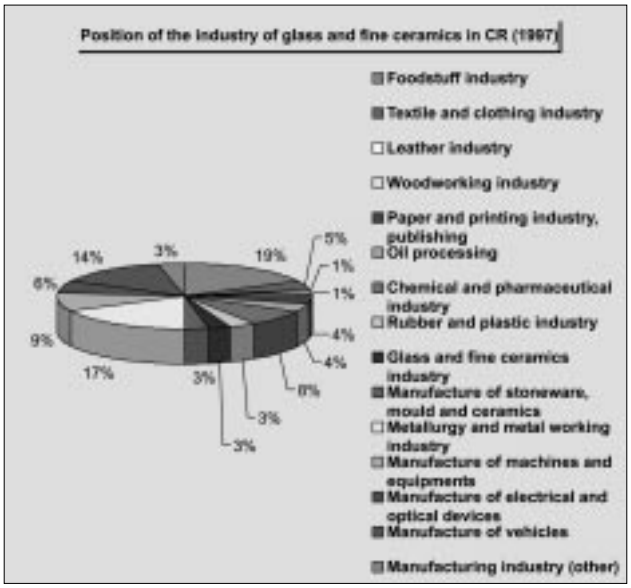

Figure 4. Position of the industry glass and fine ceramics in CR (1997)

Figure 5. Position of the industry glass and fine ceramics in CR (1998)

TABLE 1. PRODUCTION OF GLASS IN PHYSICAL UNITS (1,000 TONNES)

Group	1996	1997	1998
Sheet and construction glass	340	422	435
Container glass	372	393	385
Technical glass	52	39	61
Fibreglass	31	37	51
Tableware and lighting glass	80	79	80
Costume jewellery	18	22	19
Glass (total)	893	992	1,031

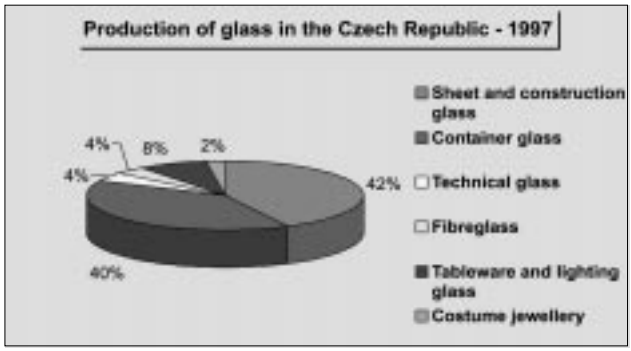

Figure 7. Production of glass in the Czech Republic (1997).

TABLE 2 PROCEEDS FROM THE SALE OF ARTICLES (1,000 MILLION CZK)

Group	1996	1997	1998
Sheet and construction glass	6.467	8.020	10.74
Container glass	2.902	3.552	3.24
Technical glass	2.887	2.863	4.40
Fibreglass	1.721	2.717	4.18
Tableware and lighting glass	6.288	7.059	7.34
Costume jewellery	6.126	6.720	7.15
Glass (total)	26.391	30.931	37.05

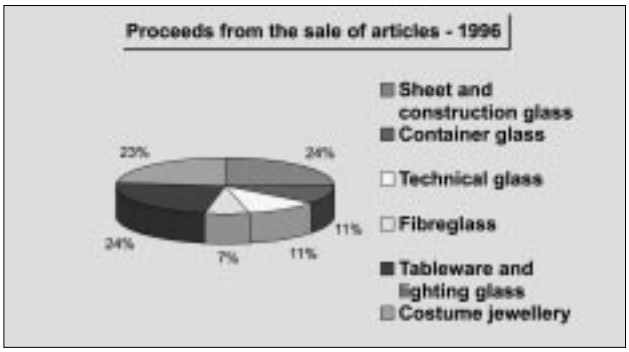

Figure 9. Proceeds from the sale of articles (1996)

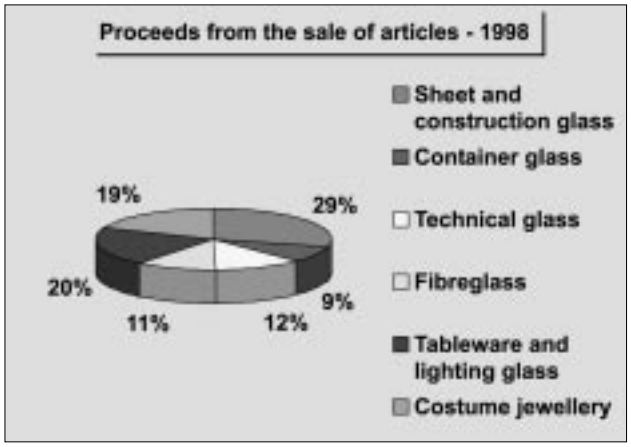

Figure 11. Figure 9. Proceeds from the sale of articles (1998)

Figure 6. Production of glass in the Czech Republic (1996).

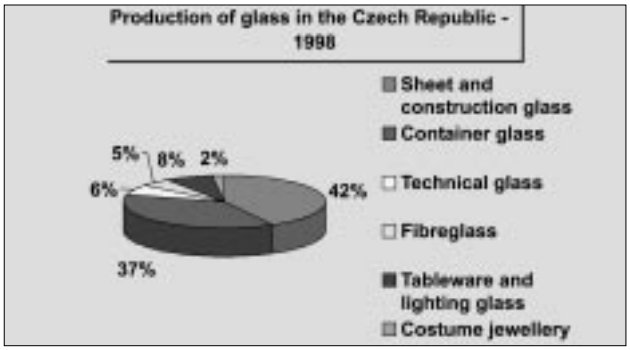

Figure 8. Production of glass in the Czech Republic (1998).

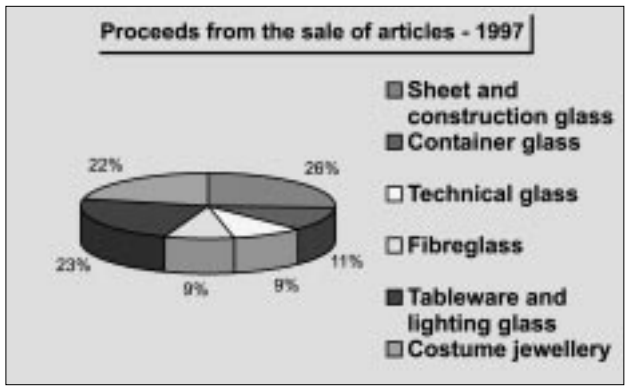

Figure 10. Figure 9. Proceeds from the sale of articles (1997)

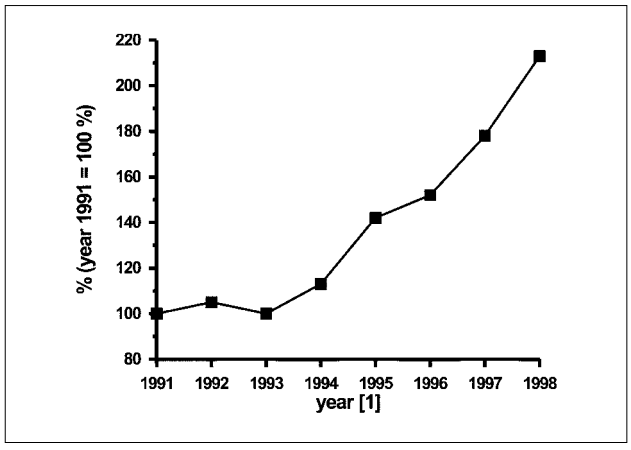

Figure 12. Increase rate for sales in white glass industry (1991-1998)

TABLE 3 EXPORTS OF GLASS (1,000 MILLION CZK)

Group	1996	1997	1998
Sheet and construction glass	4.307	4.866	5.721
Container glass	1.057	1.274	1.576
Technical glass	1.858	2.011	3.188
Fibreglass	1.106	1.910	3.030
Tableware and lighting glass	6.989	7.888	8.809
Costume jewellery	4.509	5.013	5.213
Glass (total)	19.826	22.962	27.537

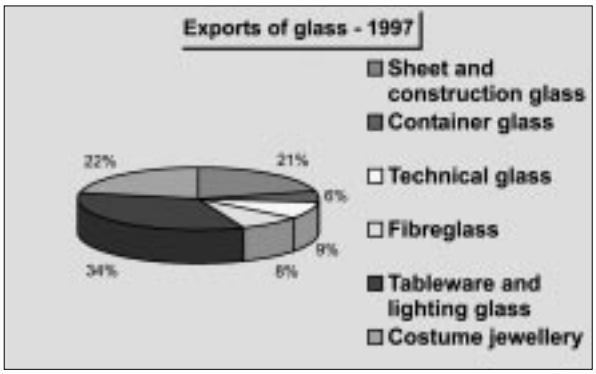

Figure 14. Exports of glass (1997).

TABLE 4 IMPORTS OF GLASS (1,000 MILLION CZK)

Group	1996	1997	1998
Sheet and construction glass	1.573	1.889	2.393
Container glass	0.402	0.461	0.408
Technical glass	0.951	1.091	1.177
Fibreglass	0.565	1.036	1.117
Tableware and lighting glass	0.910	0.946	0.788
Costume jewellery	0.013	0.009	0.014
Glass (total)	4.414	5.432	5.897

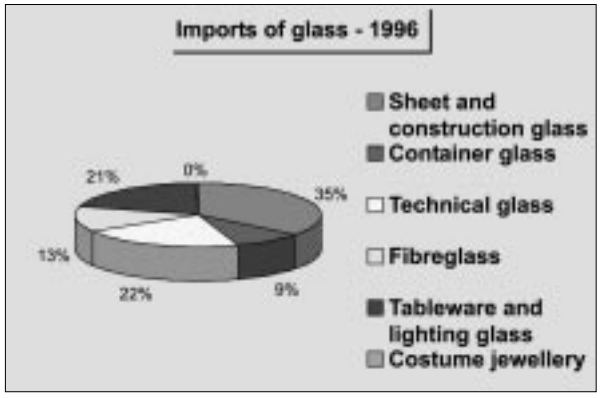

Figure 16. Imports of glass (1996).

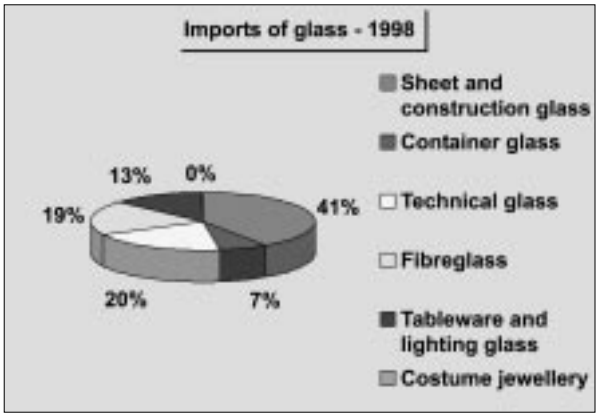

Figure 18. Imports of glass (1998).

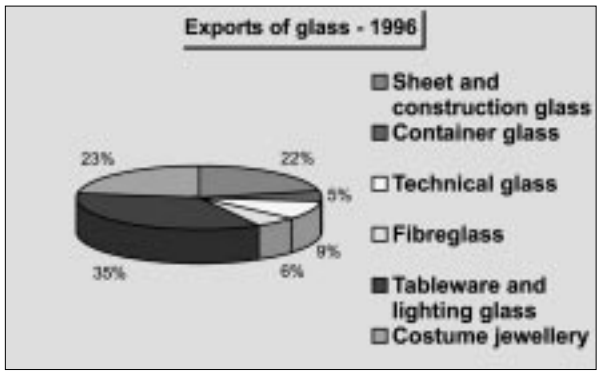

Figure 13. Exports of glass (1996).

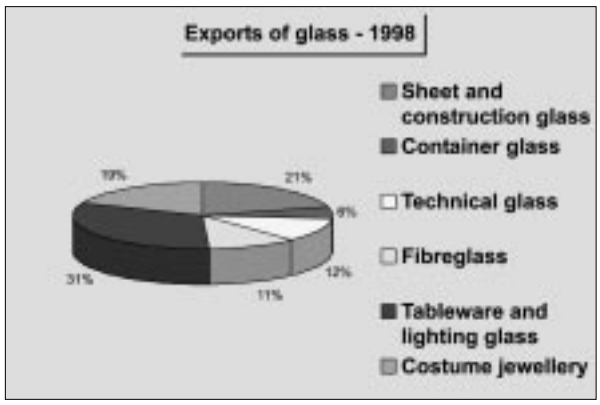

Figure 15. Exports of glass (1998).

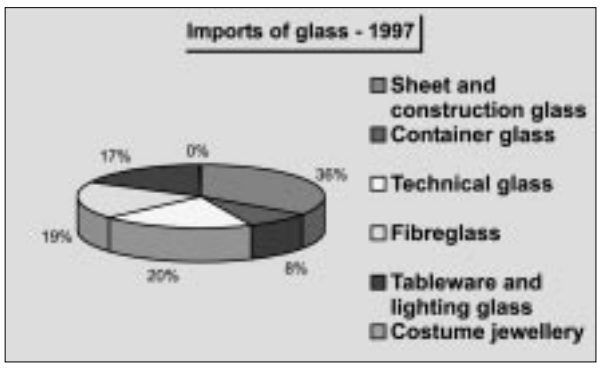

Figure 17. Imports of glass (1997).

TABLE 5 AVERAGE NUMBER OF EMPLOYEES (PHYSICAL PERSONS)

Group	1996	1997	1998
Sheet and construction glass	2,785	2,701	3,167
Container glass	1,850	1,775	1,657
Technical glass	3,307	3,300	3,215
Fibreglass	1,968	1,970	1,920
Tableware and lighting glass	16,148	13,639	12,834
Costume jewellery	12,188	12,127	11,986
Glass (total)	38,246	33,732	34,779

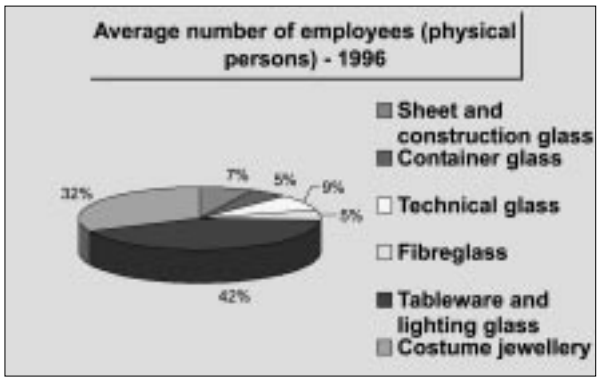

Figure 19. Average number of employees (physical persons) (1996)

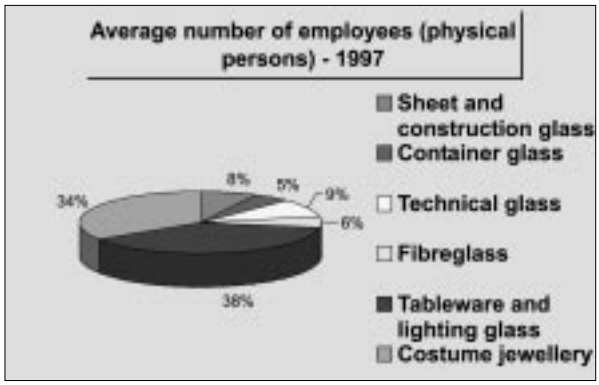

Figure 20. Average number of employees (physical persons) (1997)

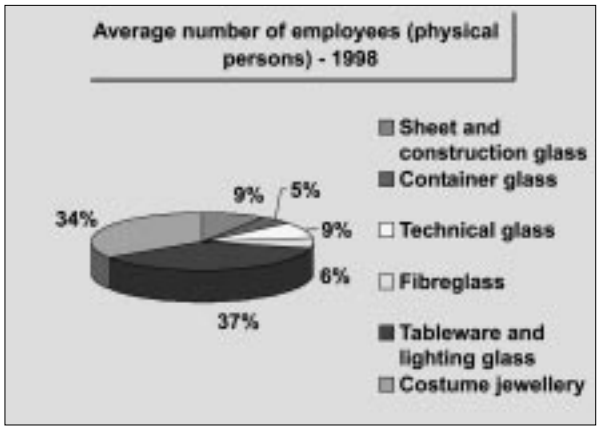

Figure 21. Average number of employees (physical persons) (1998)

3. REGIONAL LOCATION OF GLASS MANUFACTURING COMPANIES IN CR

Glass companies in CR are situated all over its area. The location, however, is not even. The highest number of these companies can be found in the North-Bohemian region - because in this region there were, and still are, necessary sources of energy (bovey coal for the manufacture of producer gas) and raw materials (glass-making sand etc.).

4. STRUCTURE OF GLASS INDUSTRY IN CR

The branch of glass industry in CR can be defined as a complex of seven aggregations:

- container glass
- fibreglass
- sheet and construction glass
- technical glass
- tableware glass
- lighting glass
- costume jewellery

It is obvious that the seven aggregations above are supported with a large complex of companies providing services and delivering raw materials, facilities etc., which are necessary to run manufacturing companies of the glass industry.

4.1. Sheet and construction glass

The company GLAVERBEL CZECH which possesses five manufacturing plants represents the monopoly producer of sheet glass in CR and the major supplier of its applications. The group GLAVERBEL CZECH includes following joint-stock companies:

- SPLINTEX CZECH, Chude¯ice
- GLAVOSTAV, Chude¯ice
- VITRABLOCK, Bílina
- CHODOGLAV, Chodov
- IDEALFENSTER, Chude¯ice
- SPIREC CZECH, Chude¯ice

The GLAVERBEL CZECH company has built a large distribution network in CR, Slovakia and Poland. The Belgian firm GLAVERBEL S.A. is a major owner of this company (99.98%).The profit-sharing of GLAVERBEL CZECH in the branch of glass industry is the largest of all glass manufacturing companies in CR, i.e. 27.5%. Main production commodities of the GLAVERBEL CZECH company are:

- float glass
- patterned and wired glass
- mirrors
- automotive glass
- architectural glass
- thin drawn glass
- glass blocks
- opaque glass

4.2. Container glass

Major producers of this kind of glass in CR are:

- AVIRUNION, Dubí (member of the group OWENS - Illinois, USA)
- VETROPACK MORAVIA GLASS, Kyjov (member of the VETROPACK Group, Switzerland)

Share of the revenue of those two companies in CR in the container glass commodity equals 89.8%. The rest of the share is divided among three smaller companies:

- Sklárny Moravia, Usobrno
- UNION Heřmanova Hut', Heřmanova Hut'
- Stölzle UNION, Heřmanova Hut'

Container glass represented in 1997 12.2% share of the CR glass industry revenue. The companies above show the following business orientation: bottles and jars made from white, green and brown container glass in a large scale of shapes and sizes for food, pharmaceutical, chemical and cosmetic industries.

4.3. Glassfibre

The joint-stock company VERTEX, Litomyšl, is the major producer of glassfibre in CR. In April 1998 the company Compagnie de Saint Gobain became the owner of VERTEX. The company's business orientation has focused on the manufacture of fibreglass and products made from it, i.e.:

- yarn
- roving
- cut fibres
- loth for the plastic fabricating and building industries

The VERTEX company shows a great rate of export - approx. 90%.

4.4. Technical glass

The manufacture of technical glass is concentrated in two companies in CR:

- Sklaárny KAVALIER, Sázava
- STV Glass, Valašské Meziříčí

While the Czech company Sklárny KAVALIER, S·zava, concentrates on the manufacture of:

- technical glass
- household heat resistant glass
- laboratory glass
- medical glass
- container glass
- made from SIMAX glass (very similar to PYREX glass),

then the company STV Glass, Valašské Meziřčí, 50% stock of which belong to the German firm Schott, concentrates only on the production of components for TV sets.

4.5. Tableware glass

Major volume of production and revenue of the tableware glass commodity in CR is provided by the following five companies:

- CRYSTALEX, Nový Bor
- SKLO BOHEMIA, Světlá nad Sázavou
- Jihlavské sklárny BOHEMIA, Jihlava
- Sklárny BOHEMIA, Poděbrady
- MOSER, Karlovy Vary

with the export rate 77%. The companies above are producing a large scale of products made from three main types of glass melt:

- Bohemian crystal (potassium – calcium)
- Barium crystal glass
- Lead crystal glass

Business activities of the companies manufacturing tableware glass are focused on the production of table glassware, domestic glassware and other tableware glass which can be plain, decorated or cut, and also on the manufacture of artistic glass objects.

4.6. Lighting glass

The company OSVĚTLOVACÕ SKLO - LARES, Valašské Meziříčí, manufacturing a large scale of lighting glass, lamps and cover glass for head lights, is the major producer of lighting glass in CR.

4.7. Costume jewellery

Czech costume jewellery industry is concentrated in the town Jablonec nad Nisou, located 100 km north of Prague, and in its close surroundings. In this region, there is present economic and business potential involving the whole scale of activities needed for manufacture, trade, development and education in this branch.

Main producers of glass costume jewellery in CR are:

- PRECIOSA, Jablonec nad Nisou
- ORNELA, Desná
- ŽELEZNOBRODSKÉ SKLO, Železný Brod

and 11 other companies.

Main commodities of this branch of industry are:

- glass chattons
- pendants
- chandeliers
- glass pearls
- glass figurines
- glass jewellery
- glass rods and tubes

5. GLASS SCIENCE AND RESEARCH IN CR

After 1989, there have appeared great changes in the structure of organizations dealing with glass science, research and development. We can say that after 1989 the research capacities in the branch of glass science and technology have decreased. At present, the following subjects are concerned with glass science and technology in CR:

1. Institute of Chemical Technology, Prague
2. Department of Glass and Ceramics
3. Institute of Inorganic Chemistry, Prague (Academy of Science of CR). Laboratory of Inorganic Materials
4. Technical University, Liberec
5. Department of Glass and Ceramics Making Machinery
6. Glass Service Ltd., Vsetín
7. VÚSU a.s., Teplice
8. Glass Institute s.p., Hradec Králové

Regional location of the research institutes above is introduced in Fig. 28.

In spite of their largely reduced capacity possibilities, these six organizations provide quite wide range of research activities. The main activities in particular organizations are:

A. Institute of Chemical Technology, Prague
Department of Glass and Ceramics

Major research activities are:

1. Physical and mathematical modelling of glass melting processes, including electric melting
2. Characterization of raw materials and products by optical and electron microscopy
3. Defects in glass and surface layers on glass
4. Chemical durability and kinetics of glass corrosion
5. Bioactive glasses and glasses for immobilization of radioactive waste
6. Historical glasses
7. Melting processes and relations between the composition and properties of glasses
8. Development of new glasses, e.g. lead-free crystal glass

B. Institute of Inorganic Chemistry
Laboratory of Inorganic Materials

Major research activities are:
1. Special glasses for optoelectronics based on chalcogenides and other non-oxidic systems
2. Electrochemical processes at the interface between electrode material and molten glass
3. Interaction of gases and vapours with molten glass
4. Mathematical modelling of melting processes with respect to chemical reactions
5. Identification of sources of gaseous inclusions in glass

C. Technical University, Liberec
Department of glass and ceramics making machinery
Major activities are:
1. Numerical simulation of glass forming processes
2. Identification, gripping and clamping of the objects with complex shapes
3. New principles and design solution of effectors of industrial robots and manipulators

D. Glass Service, Ltd., Vsetín
Major activities are:
1. Mathematical modelling of furnace design and operation
2. Glass quality troubleshooting
3. Expert system software

E. E. VÚSU a.s., Teplice
Major activities are:
1. Environmentals problems of glass manufacturing
2. Testing of products and materials in the manufacture of flat glass, container glass, pressed glass and fibreglass

F. Glass Institute s.p., Hradec Králové
Major activities are:
1. Study of glass defects by means of electron microscopy and microanalysis
2. Measuring of physical and mechanical properties of glass, including the study of relation between the composition and properties of glass
3. Durability and chemical analysis of glass

6. CONCLUSION

The present state and development of glass industry companies can be positively evaluated because the glass industry has got:
- domestic raw materials of a good quality
- products export tradition
- top staff at all levels (management, technology, manufacture, trade etc.)

The ruling plants of glass industry have restructured their production and modernized their technologies during recent years. Also glass research and development contribute to glass industry achievements, working effectively and producing valuable results which always focus on glass processing technology problems. The facts mentioned above imply that there are good expectations of further development of the Czech glass industry.

APOLOGY

Author apologizes to all other producers of glass in the Czech Republic, which are not quoted in the article because the extent of the article did not allow him to do that.

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